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SURVEY OF CABBAGE APHID POPULATIONS ON BRUSSELS SPROUTS, 1946-51

Contribution from the Conference of Entomologists, National Agricultural Advisory Service, compiled by D. W. Empson, N.A.A.S., Caversham, Reading, Berks

Although much is known of the life histories and habits of the common insect pests, we have little information about the factors that decide the population level of a species at any particular time and place. Such information might lead eventually to an understanding of the causes of pest outbreaks, and even render it possible to forecast some of them. In writing of the birth of work on insect damage assessment in this country, and of the aims of quantitative pest surveys, Thomas (1948) pointed to the Cabbage aphid (*Brevicoryne brassicae* L.) and the great variation in its populations from year to year—and even from month to month—as an example of the great difficulties facing entomologists trying to forecast insect attacks. Nevertheless, a start was made on this pest, and this contribution is a summary of the work done, year by year, from October 1946, when a standardized counting method was first adopted, until January 1951.

Although slight modifications were made in counting technique as more information became available, the general scheme of work has remained unaltered during the first five years of the survey. In each N.A.A.S. province and sub-province, five or more widely distributed fields of Brussels sprouts were examined in October and five in the following January. In October, each of 25 plants, about equally spaced on a diagonal across each field, was classified into one of four categories, according to the degree of aphid attack. In January, actual counts of live aphids and eggs were made on 10 plants (20 in 1951) in each field. The categories used in the October inspections were :

Clean	No colonies visible on outer leaves or sprouts.
Slight	One or more colonies on outer leaves, sprouts clean.
Moderate ..	One to five sprouts with colonies visible, counting top as one sprout.
Severe	More than five sprouts with visible colonies, and large enough to make them unsaleable.

An index of severity was calculated for each field, using the formula :

$$\text{Index of Severity} = \frac{\%\ \text{Slight} + 2 \times \%\ \text{Moderate} + 3 \times \%\ \text{Severe}}{3}$$

Although no figures were obtained for the number of aphids present on plants in each of the categories, it may be said that one " severe " plant certainly carried far more aphids than 1·5 " moderate " or 3 " slight " ones. An index of severity of 50, for example, indicates very much more than twice the aphid population corresponding to an index figure of 25. The index of severity chosen, however, had the merit that it placed fields in the correct order of intensity of attack, and that, like the logarithmic scale, it gave approximately the same emphasis to small changes in low populations as to large changes in high populations. Table 1 gives the mean index of severity for all the fields examined in each province or sub-province each year. Because of the large sampling and conversion errors, the figures are given to the nearest multiple of five.

(52944) A*

TABLE 1

INDEX OF SEVERITY OF APHID INFESTATION (OCTOBER)

Provinces and Sub-Provinces	*1946*	*1947*	*1948*	*1949*	*1950*	Mean (*1947–50*)
Northern	—	20	20	30	15	20
Yorks and Lancs	10	40	35	60	15	40
East Midland	25	45	30	35	30	35
Eastern	—	90	25	60	30	50
West Midland	5	40	25	50	25	35
North Wales	—	15	25	—	10	(15)
Mid-Wales	5	20	15	50	—	(30)
South Wales	—	25	45	35	0	25
South-Western (Bristol)	10	40	20	15	5	20
South-Western (Starcross)	—	15	10	15	5	10
South-Eastern (Reading)	15	55	25	20	15	30
South-Eastern (Wye)	0	50	30	35	50	40
ANNUAL MEAN	10	40	25	35	20	30

The corresponding average counts, for both live aphids and eggs, in the January following the October assessments of severity, are given in Table 2. The number of live aphids found in January was generally small, and the figures for number of eggs alone give a fair indication of the proportionate total overwintering populations in the several provinces; the figures for overwintering aphids are of interest, however, as these aphids are likely to give an earlier "build-up" of infestation than the eggs.

TABLE 2

MEAN COUNTS OF APHIDS AND EGGS (JANUARY)

Upper figures: aphids Lower figures: eggs

Provinces and Sub-Provinces	*1947*	*1948*	*1949*	*1950*	*1951*	Mean (*1947–50*)
Northern	0	0	1	8	0	2
	1	303	9	20	0	83
Yorks and Lancs	0	1	1	5	—	2
	4	271	121	29	—	106
East Midlands	0	0	0	0	—	0
	1	467	21	6	—	124
Eastern	0	97	22	0	0	30
	6	1,584	2	1	0	398
West Midland	2	7	20	1	0	8
	3	100	9	7	0	30
North Wales	16	1	73	12	0	26
	0	4	30	28	0	16
Mid-Wales	2	26	47	66	—	35
	0	1	0	0	—	0
South Wales	48	21	33	2	5	26
	0	40	2	1	0	11
South-Western (Bristol)	—	16	7	1	0	(6)
	—	146	3	0	0	(37)
South-Western (Starcross)	4	33	0	2	—	10
	0	19	0	0	—	5
South-Eastern (Reading)	12	277	19	6	5	79
	0	536	0	1	0	134
South-Eastern (Wye)	6	5	6	2	3	5
	0	1,460	2	0	1	366
ANNUAL MEAN	8	40	19	9	2	19
	1	411	17	8	0	109

Variation between fields was so great that only major differences in October indices of severity, and in January counts, can be considered significant when comparing provincial means. The national means for each year may be accepted with more confidence. Five years is too short a period to provide data on which any firm conclusions can be based, but the main indications from the survey, up to January 1951, were as follows :

REGIONAL DISTRIBUTION

Cabbage aphid populations in October are generally higher in the north and east of England than in south-west England, or Wales. The areas with highest populations are those with the drier and more continental climates (Table 1).

Populations tend to be highest in those areas that grow most brassicas :

Provinces and Sub-Provinces	Percentage of National Brassica Acreage	Mean October Index of Severity *1947–50*	Provinces and Sub-Provinces	Percentage of National Brassica Acreage	Mean October Index of Severity *1947–50*
Eastern	34	50	South-Eastern (Reading)	8	30
South-Eastern (Wye)	13	40	South-Western (Bristol)	5	20
West Midland ..	13	35	South-Western (Starcross)	5	10
Yorks and Lancs	10	40	Northern ..	2	20
East Midland ..	8	35	South Wales ..	2	25

Those areas where the October populations are highest are also those with the highest overwintering populations (Tables 1 and 2). The general validity of this indication is doubtful, as the very high egg-counts of January 1948 tend to make the 1947–50 provincial means follow this year, and the low January counts of 1948 and 1949 in the Eastern and West Midland Provinces do not support it.

YEAR-TO-YEAR VARIATION

Severity of aphid infestation in October tends to vary in a similar way in all provinces from year to year (Table 1). This tendency is fairly pronounced, and it may permit the country to be considered as a whole for comparison of mean aphid populations with year-to-year climatic changes.

There is little correlation between the severity of infestation in October and the counts of aphids and eggs in the following January ; and none between the corresponding figures for January and October in the same year (see annual means in Tables 1 and 2). This may to a large extent be due to the number of generations between any two counts.

OVERWINTERING

The winter is passed in the north and east mainly in the egg stage, and in the south and west mainly by viviparae. Even in the south-west, however, some eggs are laid in suitable years (Table 2).

When eggs are most numerous in the north and east, both eggs and aphids are also most numerous in the south and west (Table 2). But here again the high counts in 1948 had a decisive effect upon the 1947–50 means, and counts over a longer period are required.

INFLUENCES OF CLIMATE AND WEATHER

The higher aphid populations in the north and east than in Wales and the south-west indicate some correlation between climate and regional distribution, since the driest areas are on the eastern side of the country, but factors other than rainfall may well be involved.

No clear relation could be found between regional rainfall and temperatures and the year-to-year variation in aphid populations. Every "rule" that suggested itself was invalidated by one or two exceptions. In future work, when corrections for parasitism and other relevant factors can be made, the position may be clarified. Over the period 1946–50, however, it was found that :

1. On no occasion where the mean weekly temperature for the last week in October was 9° F., or more, below that of the first week in October was there a high January count of eggs or aphids.

2. The national mean index of severity of infestation in October was greatest when the previous August was warm and dry ; and least when it was cool and wet.

Year	October Index of Severity	Mean Air Temperature in August. Deviation from Average	Rain-days in August. Deviation from Average
		deg. F.	
1947	40	+ 5·2	− 12
1949	35	+ 2·3	− 6
1948	25	− 0·8	+ 1
1950	20	+ 0·3	+ 3
1946	10	− 1·7	+ 5

No consistent climatic differences could be found between areas in which overwintering was predominantly by eggs and those in which significant numbers of aphids took part. Any climatic factors affecting this must operate before, or at latest, during, the production of oviparous females and males. It would seem therefore that hard winters have little effect on overwintering, apart from killing of viviparous forms. There appeared to be some correlation between egg production and hot dry weather in the summer, but this may have been entirely due to the peak year, 1948, as eggs were few following the warm summer of 1949.

This exploratory survey work was carried out by the staff of N.A.A.S. Provincial Entomology Departments under the direction of the Conference of Advisory Entomologists and the Plant Pathology Laboratory, Harpenden. The Pest Assessment Committee is now investigating improved methods for the estimation of insect populations, with special reference to Cabbage aphid, and the work is being continued in much greater detail.

We thank the Agricultural Branch of the Meteorological Office, for the provision of weather data and help in their interpretation ; and the Statistical Department, Rothamsted Experimental Station, Harpenden, for the examination of field data and subsequent advice on sampling procedure.

REFERENCE

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THE RAPID ASSESSMENT OF APPLE SCAB ON LEAVES

by H. E. Croxall, D. C. Gwynne and J. E. E. Jenkins

National Agricultural Advisory Service, Newcastle-on-Tyne and Evesham, Worcester

Apple Scab is a difficult disease to assess in the field. The degree of infection may vary considerably from tree to tree, and the amount of scab on the fruit, which is of chief concern to the grower, may not always be at all closely related to that on the leaves. For a number of good reasons, however, a rapid method of assessing scab on the leaves is much needed. Leaf infection provides a reservoir from which the disease may spread to the fruit ; and by reducing photosynthetic area, it may reduce tree growth, and retard development. In spraying trials, it is often necessary to rely on leaf assessments for comparison of the effects of treatments, since, owing to such factors as spring frost and biennial bearing, fruit may be almost absent in some seasons.

Methods of assessing the amount of scab on leaves, based on the taking of leaf samples and their comparison with standard diagrams, have been published by Tehon and Stout (1930), and by Kearns, Marsh and Martin (1945). These methods, though well-adapted for research purposes, are too time-consuming for use in general survey work. The development of more rapid methods was begun in 1941 by a Disease Measurement Committee of the British Mycological Society (Moore, 1943). Since that time, several types of key have been tried, each more nearly approaching what is required in practice, but each having some drawback, either in that it was still too slow in use, or because it gave results in an inconvenient or arbitrary form.

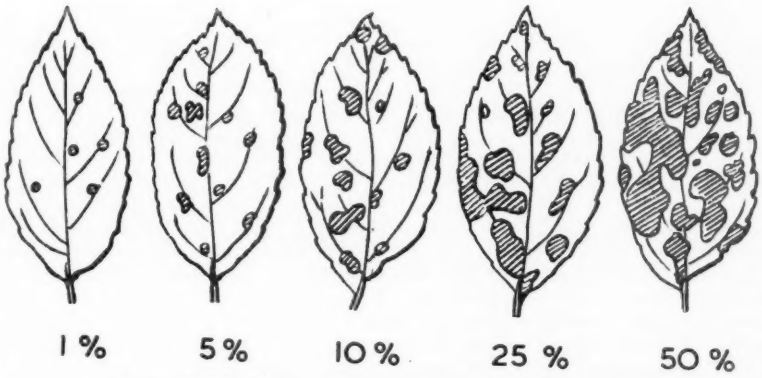

Fig. 1. Standard Diagram for assessment of Apple Scab on leaves.

In 1949, one of us (D.C.G.), while working on a spraying trial in Westmorland, where trees at various levels of infection were available, was able to carry the method of visual assessment a stage further, and a revised key, based on this

work, was issued for trial within the National Agricultural Advisory Service in 1950. In 1951, we found that some additional stages were desirable in the lower ranges of infection, for, as Kearns, Marsh and Martin have pointed out, a scab attack, in which only 1 per cent of the leaf area is covered by lesions, bears the appearance of a moderately heavy infection, and in practice, it is the lower part of the scale which is most frequently needed. The revised visual key was as follows :

KEY FOR APPLE SCAB ON LEAVES

On each tree, five runs of branches, chosen at random round the tree, are taken as sampling units. A " run " of branches consists of a main branch and all the laterals, sub-laterals and spurs on it. The appearance of all five units is taken into account in assessing the percentage of scab on the tree as a whole. Where possible, recordings should be made on ten trees of each variety.

Scab *per cent*	
0·01	Occasional units show one or two infected leaves.
0·05	Scab spots on one or two leaves in each unit.
0·25	Every unit shows up to five small spots or their equivalent on about one-quarter of the leaves.
0·5	Every unit shows five small spots or their equivalent on about half the leaves.
1·0	Majority of leaves infected, a few with about 25 per cent of their area covered with spots.
5·0	Almost every leaf infected with the scab areas covering approximately 25 per cent of the leaf surface on about one-quarter of the leaves.
10·0	Every leaf infected with the scab areas covering approximately 25 per cent of the leaf surface on half the leaves.
25·0	Every leaf infected with the scab areas covering 50 per cent of the leaf surface on half the leaves.
50·0	All leaves infected, with the scab areas covering almost the entire leaf surface on about half the leaves.

Notes :

1. If only a single observation can be made, it should be at three to four weeks after petal fall.
2. The incidence of scab on fruitlets should be noted and recorded as nil, slight, moderate or severe.
3. Note should be taken of the general condition of the trees and their management, including ages, rootstock, other diseases and pests, whether grassed or cultivated or intercropped, distance apart of trees, and spraying programme, if any.

We (H.E.C. and J.E.E.J.) used this key in 1951, for the assessment of scab on observation plots sprayed with a number of materials near Worcester, and with the co-operation of R. W. Marsh and R. J. W. Byrde, we tested it against the more accurate research method of Kearns, Marsh and Martin (1945). The plots were on a block of Worcester Pearmain in a farm orchard, which was overgrown with tall grass, so that conditions favoured scab development. Two plots were unsprayed, and six others were sprayed at pink-bud, petal fall, and three weeks later, with two preparations of glyoxalidines, ziram (zinc-dimethyldithiocarbamate), thiram (tetramethlythiuramdisulphide), a mercury compound, and lime sulphur, respectively. Our visual assessments by the key were made on June 27 and July 4, and the other assessments, by Marsh and Byrde, on August 8. Their method was to take a sample of leaves from a conical section of each of four trees in each plot, the apex of the cone being at

the trunk. From each sample 250 leaves were taken at random and compared with the diagrams of Tehon and Stout. Similar diagrams, based on leaves collected during the trial, are given in Fig. 1. The leaves were sorted into groups according to three ranges of leaf infection ; 0 to 2½ per cent, 2½ to 7½ per cent, 7½ to 12½ per cent ; the number of leaves in each group was multiplied by the mean percentage for the group, the products were added, and the result was divided by the total number of leaves examined. In this way, a mean percentage of scabbed area per leaf was obtained. The results by this and by the visual method are given in the following table :

TABLE 1

COMPARISON OF ASSESSMENTS OF APPLE SCAB ON LEAVES BY "VISUAL" AND "RESEARCH" METHODS ON PLOTS OF WORCESTER PEARMAIN, AT WORCESTER, 1951

Spray Material used on Plot	Visual Method June 27	Visual Method July 4	Research Method August 8	
			Range over four trees	Mean
	Percentage	*Percentage*	*Percentage*	*Percentage*
Unsprayed control (A) ..	1·4	3·5	1·9–3·8	2·8
Unsprayed control (B) ..	0·9	2·2	1·7–2·9	2·4
Glyoxalidine (A)	0·6	0·8	0·4–1·0	0·7
Ziram	0·4	0·8	0·3–0·8	0·7
Thiram	0·3	0·9	0·3–0·9	0·6
Glyoxalidine (B)	0·3	0·3	0·1–0·4	0·3
Mercury compound	0·2	0·2	0·3–1·3	0·6
Lime sulphur	0·1	0·2	0·5–0·4	0·3

Although there were some discrepancies, the results obtained by the two methods showed reasonably close agreement. The main discrepancy occurred in the plot sprayed with the mercury compound, but here the trees sampled by Marsh and Byrde included one with much more scab (1·3 per cent) than the remainder, and this tree was not included in those assessed by the visual method.

The visual method cannot be expected to have the same degree of accuracy as the more elaborate research method, and no doubt the visual key will be further improved in use, but the present trials indicate that it may safely be used to detect major differences in a spraying trial, and to follow the course of the disease through the season, as well as for general survey work. An account of a similar method for the estimation of scab on fruit is in preparation.

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THE IDENTIFICATION OF APHIDS OF ECONOMIC IMPORTANCE*

by H. L. G. STROYAN

Department of Zoology, University of Cambridge

BRACHYCAUDUS Van der Goot

Theobald (**2**, 220) following Baker, does not separate *Brachycaudus* from *Anuraphis* Del Guercio, and the use of his account of *Anuraphis* cannot be recommended to inexperienced workers.

GENERIC CHARACTERS

Rather small to medium-sized aphids, green, dark green or ochreous-reddish. Frons slightly sinuate, convex medially and with very low lateral prominences. Antennae short to medium length, imbricate, without rhinaria in apterae; in alatae with rhinaria on III, III–IV or III–V inclusive, irregularly arranged. Processus terminalis 3 or more times basal part of VI. Spinal tubercles never on head (except very rarely in the subgenus *Appelia*), occasionally on abd. VIII, but usually quite absent. Abdominal dorsum in apterae variably sclerotized, but frequently completely sclerotic or with only intersegmental or spinal lines of weakness. Spiracles widely open, sub-circular.

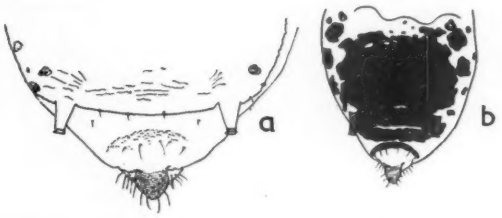

Fig. 5. *Brachycaudus helichrysi* (Kalt.)

a. Posterior part of abdomen, apt. v. ♀ b. Abdominal pattern, al. v. ♀

Siphunculi very short to moderate in length, nearly smooth, cylindrical or tapering, distinctly flanged and usually with a preapical striate circumcision. Cauda short, not or hardly longer than broad, semicircular, tongue-shaped or sub-pentagonal with a slight basal constriction. Body never mealy or waxy. The genus is close to *Sappaphis* Matsumura, which differs in the presence of spinal tubercles on the head and in the smaller, more reniform spiracles, as well as in its primary host relations.

ECONOMY

Typically, the species of *Brachycaudus* migrate from primary hosts among the Prunoidea to herbaceous plants among the Compositae and Scrophulariaceae. All three of the species likely to damage fruit trees in Britain have this type of biology. They can be keyed as follows (applicable to only *Prunus* forms):

1 (2) Dorsum hardly pigmented in apterae, sometimes pale-brownish but never blackish sclerotic. Siphunculi pale . . . . *B. helichrysi Kalt.*

2 (1) Dorsum with sclerotic areas heavily blackish pigmented. Siphunculi more or less darkened.

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* Continued from *Plant Pathology*, 1952, **1**, 11–15.

3 (4) Body, frontal and antennal hairs rather long and acute, as long as or longer than diameter of ant. III in apterae. Alatae with rhinaria on ant. III and IV only. . . . . (*Appelia*) *tragopogonis* Kalt.

4 (3) Body, frontal and antennal hairs, except on abd. VIII, very minute and blunt, less than one-quarter diameter of ant. III in apterae. Alatae with rhinaria on ant. III–V inclusive . . . *prunicola* Kalt. (*persicae-niger* Smith, *masseei* Theob.)

A possible difficulty is the occurrence also on *Prunus* of the common *B. cardui* (L.), the apterae of which run down to *B. prunicola* in the above key. Such apterae should be submitted to a specialist, but if alatae are present, separation is easy because they have rhinaria on ant. III only. *B. helichrysi*, besides being a pest on species of *Prunus*, curling the leaves very badly, may also severely damage various secondary hosts, including clover, asters and chrysanthemums.

LITERATURE: There is at present no readily accessible paper dealing in a practical way with the genus *Brachycaudus*. Börner's account (**5**, 581) is useful; his genera *Appelia* and *Brachycaudina* may be considered subgenera of *Brachycaudus*.

CAVARIELLA Del Guercio

There are no important generic synonyms of *Cavariella*.

GENERIC CHARACTERS

Small to medium-sized green, straw-coloured or ochreous-reddish aphids. Body rather elongate and a little flattened. Frons medially rather convex, lateral prominences rather low, not higher than median prominence. Antennae rather short in apterae, without rhinaria; longer in alatae, with tuberculate rhinaria along whole length of III, and sometimes with up to 6 on IV. Cuticle in apterae strongly sclerotic with pitted sculpture, but not pigmented or at most very pale-yellowish. Alatae with a rather trapezoidal black patch on dorsum in front of the siphunculi, usually with lines of weakness along the intersegments. The precaudal tergite bears medially a backwardly projecting process, bearing 2 hairs at its apex; this is usually larger and longer in apterae than in alatae. Siphunculi cylindrical or clavate, strongly rugose or imbricate except on the swollen part if clavate; with a small rim, hardly a flange, at apex; very distinctly longer than the cauda which is rather blunt, rather tapering in alatae but less so in apterae, with about 6 hairs. The supracaudal process on the precaudal tergite is diagnostic for *Cavariella*, except that such a process is also found in *Cavahyalopterus* Mimeur, in which, however, the siphunculi are much shorter than the cauda.

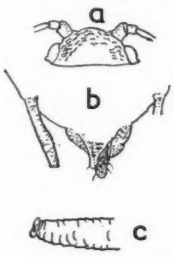

Fig. 6. *Cavariella aegopodii* (Scop.) apt. v. ♀

a. Head. b. Posterior part of abdomen, showing siphunculus, cauda and supracaudal process. c. Apex of siphunculus, further enlarged.

ECONOMY

Cavariella migrates from various *Salix* species to Umbelliferae, where it lives in the umbels, on the stems of the umbels or under the upper leaves. *C. aegopodii* (Scop.), can be a serious pest on carrots. It is a small species with clavate siphunculi and the processus terminalis less than twice the basal part of VI, and with rhinaria only on ant. III in alatae. This combination of characters is diagnostic.

LITERATURE : A page of discussion of *Cavariella*, with a key to the western European species, is given by Hille Ris Lambers in "On some mainly Western European Aphids" (*Zool. Meded.* 1947, **28**, 310).

CRYPTOMYZUS Oestland

Theobald (**1**, 226) places what is now *Cryptomyzus ribis* (L.) in his *Capitophorus*, sinking *C. galeopsidis* Kalt. (a good species) as a synonym, and erecting a new species *C. whitei* which is apparently a synonym of *C. ribis*. Theobald's *Rhopalosiphum alboapicalis* (**2**, 70) is also a species of *Cryptomyzus*.

GENERIC CHARACTERS

This is one of a small number of genera of the Aphidinae having the body adorned with prominent capitate hairs. Of these, only *Cryptomyzus* and *Pentatrichopus* Börner are of any importance to economic entomologists. *Cryptomyzus* is a genus of pale whitish, straw-coloured or very pale green aphids of fragile appearance. Head and body adorned with capitate hairs arranged in longitudinal spinal, pleural and marginal series. Antennae in apterae (except fundatrices) with a small group of tuberculate rhinaria at the base of joint III ; alatae with rhinaria along whole of III and IV, and rather fewer along V. Processus terminalis very long, more than 5 times basal part of joint VI. Dorsal cuticle in apterae smooth, colourless and membranous. Alatae with a more or less defined blackish dorsal patch in front of siphunculi, though it may be broken up by colourless lines or patches. Siphunculi slender, from about $1\frac{1}{4}$ or more than $3\frac{1}{4}$ times cauda in length, usually very slightly widened or clavate distally, nearly smooth on distal half, with a very small flange. Cauda rather blunt, from hardly to distinctly elongate, with few hairs. Closely related to *Cryptomyzus* is *Capitophorus* Van der Goot, in which, however, the apterae are without rhinaria, and the biology is typically a heteroecy from Elaeagnaceae to Compositae.

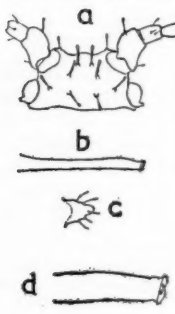

Fig. 7. *Cryptomyzus ribis* (L.) apt. v. ♀
a. Head. b. Siphunculus. c. Cauda. d. Apex of siphunculus, further enlarged.

ECONOMY

Typically, *Cryptomyzus* migrates from species of *Ribes* to various Labiatae, but there are also anholocyclic forms living continuously on Labiatae, and biological races of the heteroecious species which remain on *Ribes* through the summer. Only the *Ribes* forms are of any importance for this paper. Of these, *C. ribis*, the genotype, forms the well-known red blister galls on red currant, and very much more rarely on other species ; while *C. galeopsidis* lives under the leaves of various species of *Ribes* without causing any reaction. In *C. ribis*, the siphunculi are more than three times as long as the cauda ; in *C. galeopsidis*, less than twice the cauda. Exules of these species on Labiatae are very easily confused with the anholocyclic forms *C. alboapicalis* and *C. korschelti* Börner, and identification of forms on Labiatae should therefore be left to a specialist.

LITERATURE : No complete and up-to-date account of *Cryptomyzus* is available at the time of writing.

MACROSIPHUM Passerini

Theobald (**1**, 55) described many species of *Macrosiphum* of which the large majority properly belong to other genera. In the present conception of *Macrosiphum*, the only important species are *M. gei* (Koch) and *M. rosae* (L.). The former species is composite, and contains the pink and green potato aphid *M. euphorbiae* (Thomas) (syn. *solanifolii* Ashmead).

GENERIC CHARACTERS

Large spindle-shaped pink or green aphids, with long legs and antennae, the latter usually longer than the body. Frons with rather high, smooth, divergent lateral prominences. Antennae in apterae with very few (*M. euphorbiae*) to rather many rhinaria (*M. rosae*) on basal one-sixth to one-half of joint III ; alatae with rhinaria over whole length of III. Apterae with spinal body hairs never arising from small sclerotic spots. Siphunculi long, cylindrical or with a small trace of expansion shortly before apex, imbricate, flanged and with a zone of regular polygonal reticulations covering the preapical one-tenth to one-sixth. Cauda very elongate, ensiform with acute apex, with 8–20 hairs more or less arranged in pairs. Closely related genera are *Sitobion* (to be described later), *Dactynotus* Raf. (bronze-brown aphids on Compositae and Campanulaceae, with spinal hairs arising from scleroites), *Macrosiphoniella* Del G.(green to dark brown, often pulverulent aphids with flangeless reticulate siphunculi, living almost always on species of Anthemideae) and *Masonaphis* H.R.L. (with distinctly swollen siphunculi, reticulate at apex, living on azaleas).

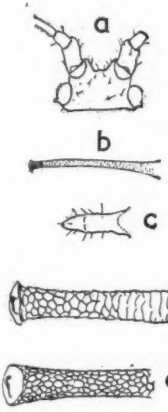

Fig. 8. *Macrosiphum* Pass.
a. Head of *M. gei* (Koch) apt. v. ♀
b. Siphunculus of *M. euphorbiae* (Thomas) apt. v. ♀
c. Cauda of same.
d. Apex of siphunculus, further enlarged.
e. Ditto of *Macrosiphoniella persequens* (Walker).

ECONOMY

Typically, *Macrosiphum* uses Rosaceae as primary hosts, with a migration to various herbaceous plants (Dipsacaceae, Umbelliferae, Valerianaceae, etc.) in summer. *M. rosae* is too well-known to need description ; its entirely black siphunculi separate it from all the other British species. It migrates in summer to various species of *Scabiosa*, to *Dipsacus* and to *Centranthus* ; and has on some occasions been found in small numbers on holly. *M. euphorbiae* is an extremely polyphagous pest whose chief economic host is potato, on which it is the only species with reticulate siphunculi. It is abundant also on a great number of garden plants, and may produce sexuales on roses. A strong resemblance to *M. euphorbiae* is shown by *Macrosiphoniella persequens* (Walker) on tansy and chrysanthemums ; but the siphunculi here are flangeless at the apex and reticulate over more than one-third of their length (Fig. 8.e).

LITERATURE : Hille Ris Lambers (*Temminckia*, **4**, 71).

METOPOLOPHIUM Mordvilko

Theobald (**1**, 135) placed *Metopolophium dirhodum* (Walker) in *Macrosiphum*, and *M. festacae* (Theobald) in *Myzus* (**1**, 335). Two other species which he describes as *Myzus myrmecophilus* Theobald and *Myzus longipennis* (Buckton) are synonyms of *M. dirhodum*.

(52944) A** 2

GENERIC CHARACTERS

Pale green to brownish-green or pale yellowish aphids of medium to fairly large size. Head in apterae with well-marked, nearly smooth or slightly wrinkled, rather divergent lateral prominences (they may come to diverge much more if crushed in mounting), and a rather distinct though lower median prominence. Siphunculi cylindrical, rather expanded at base ; pale, moderately imbricate, not reticulate apically, and with a small to moderate apical flange. Cauda elongate, rather blunt, with 5–12 hairs more or less in lateral pairs. Rostrum with apical joint short, sub-triangular, with rather straight sides. Apterae not as a rule pigmented, but there may be a diffuse smoky sclerotization of the dorsum. In alatae there may be a pale to dark abdominal pattern of marginal sclerites, or no pigmentation at all. Secondary rhinaria in alatae on III only, in a single row along the joint ; in apterae only 0–3 at the extreme base of III. The genus is closely related morphologically to *Acyrthosiphon*, but the median frontal prominence and biological association with Gramineae make confusion unlikely.

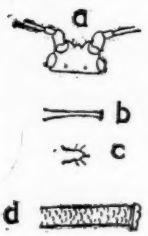

Fig. 9. *Metopolophium frisicum* H.R.L., apt. v. ♀
a. Head. b. Siphunculus. c. Cauda.
d. Apex of siphunculus, further enlarged.

ECONOMY

Five British species are known, of which two are of no economic importance. Of the other three, *M. dirhodum* is heteroecious between *Rosa* and many species of Gramineae, *M. festucae* spends the whole year on Gramineae, often overwintering viviparously ; and *M. albidum* H.R.L. normally lives only on *Arrhenatherum elatius* (*avenaceum*), but may occur on other grasses during the summer in years of abundance. Apterae of *M. dirhodum* are of a rather glaucous green when alive, with a darker green spinal stripe running along the body, and with the antennal joints darkened at the apices and around the primary rhinarium on VI. In both the other species, the antennae are progressively darker from base to apex, without apical darkening of the joints. *M. festucae* is generally commoner than *M. dirhodum* ; it is of a uniform slightly yellowish or grass green colour, without a spinal stripe. It lives on many grasses and cereals, including species of *Festuca*, *Poa* and *Lolium*, and an early attack may sometimes stunt winter oats. *M. albidum* is pale straw-coloured to yellowish-green in colour and its siphunculi are more slender apically than those of *M. festucae*. The ratio of siphuncular length to their least diameter gives values ranging from 9·5 to 12·5 in *M. festucae* apterae, with a mean of 11·3 for the material examined ; in *M. albidum*, this ratio varies from 13·2 to 18·5, with a mean of 15·4. The antennae of *M. albidum* are as a rule about equal to, or slightly longer than, the body, while those of *M. festucae* are distinctly shorter than the body.

LITERATURE : Hille Ris Lambers (*Temminckia*, **7**, 272).

MYZUS Passerini

As described by Theobald (**1**, 283) *Myzus* includes very many species which now fall into synonymy or are placed in other genera such as *Aulacorthum*, *Nasonovia*, *Metopolophium* and *Tubaphis*. As here described, *Myzus* includes the Cherry Black Fly, *M. cerasi* (F.), which is the genotype ; the Peach-Potato aphid *M. persicae* (Sulz.) ; the Shallot aphid, *M. ascalonicus* Doncaster ; the Violet aphid, *M. ornatus* Laing ; and various related species. Börner considers *M. persicae* to belong to *Myzodes* Mordv., of which (under the name *M. tabaci* Mordv.) it is the genotype. Here it is treated as a *Myzus*.

GENERIC CHARACTERS

Rather small to medium-sized green, brownish, or blackish to shiny black aphids, sometimes rather flattened. Head with well-developed, rather convergent and roughened or scabrous lateral frontal prominences (this convergence is less marked in *M. ascalonicus*), the frons between them being only slightly if at all convex. Antennae in apterae usually rather curved and without secondary rhinaria; in alatae with secondary rhinaria as a rule on III only, in a row along the joint; but in *M. ascalonicus* frequently on III to V inclusive. Dorsal cuticle of apterae uniformly sclerotic, often rugose, varying from nearly colourless to deep blackish sclerotic; generally without a well-defined pattern, but in *M. ornatus* Laing with segmental pairs of pigmented intersegmental sclerites. Alatae with a solid pigmented area occupying the mid-abdominal dorsum from segments 3 to 6, and further segmental bars on 7–8 and usually on 1–2. Separate marginal sclerites, usually bearing marginal tubercles, are often present from segments 1–5 or 2–5 in the alatae, and also in the apterae of the *M. cerasi* group. Scattered spinal tubercles may also occur in a number of species, especially on the thorax and seventh or eighth abdominal segments. Siphunculi rather long, tapering, subcylindrical or clavate, usually distinctly flanged; often scabrously imbricate, variably pigmented, rarely quite pale. Cauda rather acutely triangular, with rather few hairs arranged more or less in lateral pairs. Hind tibiae in immature forms nearly always with fine spinules scattered between the normal tibial hairs.

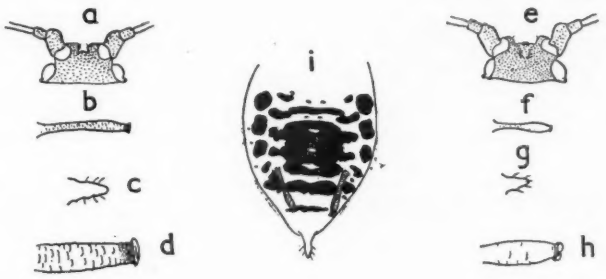

Fig. 10. *Myzus persicae* (Sulzer), apt. v. ♀

a. Head. b. Siphunculus.
c. Cauda.
d. Apex of siphunculus.

Myzus ascalonicus Doncaster, apt. v. ♀*

e. Head. f. Siphunculus. g. Cauda.
h. Apex of siphunculus.
i. Abdominal pattern of al. v. ♀

ECONOMY

Although primarily associated with Rosaceae, *Myzus* contains three highly polyphagous species which are very important pests. *M. persicae* is the most important known vector of potato virus diseases; it attacks a great variety of secondary hosts, on which it may overwinter viviparously, but overwinters as eggs on peach or, with some difficulty, on *Prunus serotina* (Hille Ris Lambers, 1951). Both *M. ascalonicus* and *M. ornatus* appear to be anholocyclic, and are equally if not more polyphagous than *M. persicae*. There is a group of monophagous species very similar to *M. persicae*, but attacking respectively only *Viola*, Caryophyllaceae, *Ajuga* and *Myosotis* during the summer. Trapped alatae of these species cannot be separated from *M. persicae*. *M. cerasi* can cause extensive curling of the terminal leaves of cherry and produce much objectionable honeydew; its summer forms and some closely related monophagous species occur on species of *Galium* and on *Veronica*.

* The lateral prominences appear to diverge in mounted specimens.

Key to the important species of *Myzus* (apterae only):

1 (4) Siphunculi cylindrical or slightly tapering towards apex. Dorsum strongly pigmented or with a pigmented intersegmental pattern. Body somewhat flattened.

2 (3) Dorsum uniformly dark brown to black sclerotic, and siphunculi black. Primary host—cherry, leaf curling . . . *M. cerasi* F.

3 (2) Dorsum pale sclerotic, with pigmented paired intersegmental sclerites which are clearly visible in life. Colour pale, dull green. Anholocyclic, very polyphagous. Siphunculi pale . . . *M. ornatus* Laing.

4 (1) Siphunculi slightly to distinctly swollen towards apex, except in early spring forms on *Prunus* or peach. Dorsum pale and without conspicuous pigmented pattern. Body not appreciably flattened.

5 (6) Siphunculi longer than III, and less swollen, with extreme tip darker than the rest and with a well-marked flange. Primary host—peach or *Prunus serotina* . . . *M. persicae* Sulzer.

6 (5) Siphunculi shorter than III, more swollen, evenly coloured throughout and with only a very small flange. Anholocyclic, extremely polyphagous. . . . *M. ascalonicus* Doncaster.

LITERATURE: There is no recent paper on the genus *Myzus* as a whole. Börner (*NachrBl. dtsch. PflSchDienst.*, 1951, n.s. **5**, 101–11) has published a short paper on *M. persicae*.

(*To be continued*).

UNUSUAL CHRYSANTHEMUM EELWORM SYMPTOMS

by J. F. SOUTHEY

Plant Pathology Laboratory, Harpenden, Herts

The typical and well-known symptoms of attack by *Aphelenchoides ritzema-bosi* (Schwartz) Steiner on chrysanthemums are blotching and dying off of the lower leaves, but a number of eelworm-infested plants examined at Bristol in 1950 and at Harpenden in 1951 showed, in addition, striking distortions of the younger leaves around and below the apical buds (Plate III, 2). Severe puckerings of the lamina were often accompanied by brown scarred areas, reminiscent of the so-called " feeding areas " seen on strawberry leaves attacked by *Aphelenchoides* species. Similar scarred areas were sometimes present on the shoot axis. Some leaves also showed an irregularly distorted margin, with raised areas of puffy appearance often tending to follow the main veins. Other leaves were reduced to a simple spatulate or linear form, with the surface and tissues otherwise apparently healthy.

Leaves from plants received at Bristol in 1950, from a number of localities in the south-west, were teased in water and, although eelworms were present in the blotched lower leaves, none was found in the distorted upper ones. On dissecting the apical buds, however, eelworms were found in varying numbers among the leaf rudiments and around the growing point, where they were evidently feeding ectoparasitically as in strawberries. Some, if not all, of the

subsequent leaf distortions were probably due to such early feeding. A plant from Surrey, examined at Harpenden in 1951, again showed these leaf distortions as well as the usual eelworm symptoms. Some of the apical buds were blind, resulting in outgrowths of lateral shoots, some of which had also been attacked. Dissection of the buds again revealed external eelworms around the growing points. Staining with Flemming's solution by Godfrey's technique, and sectioning showed small numbers wedged between young leaf-rudiments and around the growing point, which was sometimes shrivelled and blackened. Some of the eelworms were coiled up and entangled among the plant hairs. None was seen within the plant tissues. One young leaf, about 3 mm. long, stained whole, showed a small colony of eelworms of various sizes, with eggs, on the surface of the leaf base, indicating that the eelworms were reproducing in this situation. No eelworms were found associated with the lesions or " feeding areas " on leaves, but Mr. S. W. Rolfe, at Wye, informs me that he has found them in scrapings from these areas.

The unusual form of damage was evidently quite widespread in 1951. It was recorded in the South-Western (Bristol) Province in March, September and December ; and, in December, 70 per cent of the samples of infested plants showed evidence of ectoparasitic damage. In April, cases were reported from Reading, where growing points were destroyed ; and in May, at Wye, where eelworms were causing blindness in rooted cuttings although there was no blotching of the lower leaves. Numerous cases were also reported from Wye in October and November, with symptoms agreeing with those here described. At least seventeen commercial varieties have been affected in this way.

It seems clear that *Aphelenchoides ritzema-bosi* can cause two distinct kinds of damage to chrysanthemums, depending upon whether it is feeding endoparasitically in the lower leaves, or ectoparasitically in the buds. It has not been established, however, that all the symptoms associated with its presence in the buds are the effects of eelworm alone ; careful inoculation experiments are needed to determine the symptomatology of this form of the disease and the conditions governing its appearance. Reference to the literature indicates that this kind of injury has been noticed in the past, but its relationship to the more usual leaf-blotching symptoms was not fully appreciated. Smith (1926), Steiner and Buhrer (1933), and Edwards (1934) give descriptions and photographs of leaf distortions associated with chrysanthemum eelworm, which agree in general with the present observations. Goodey (1933) mentions similar symptoms on rooted cuttings, and Goffart (1930) describes browning of the epidermis on the shoot axis where young leaves were attacked.

I thank Mr. L. N. Staniland of the National Agricultural Advisory Service, Bristol, for the photograph reproduced on the right in Plate III, 2.

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ROOT ROT OF CROCUS CAUSED BY *PYTHIUM ULTIMUM*

by J. A. TOMLINSON

Plant Pathology Laboratory, Harpenden, Herts

In November 1950, some young, well-sprouted crocus corms, variety Remembrance, from Leeds, were sent to me by Dr. I. F. Storey. The corms had been forced in a greenhouse for early flowering but, after a good start, had shown arrested development. The corms themselves were healthy, but many of the roots had been cut short by a bright orange-coloured rot, and were dull and water-soaked. Isolated orange-coloured lesions, up to a quarter of an inch in length, were also present on many roots. Abundant aseptate mycelium and oospores were found in the affected areas. The fungus was isolated in pure culture and identified as *Pythium ultimum* Trow. The symptoms recalled those of Root Rot of tulip caused by species of *Pythium* (Moore and Buddin, 1937), but no previous record of a similar disease of crocus could be traced.

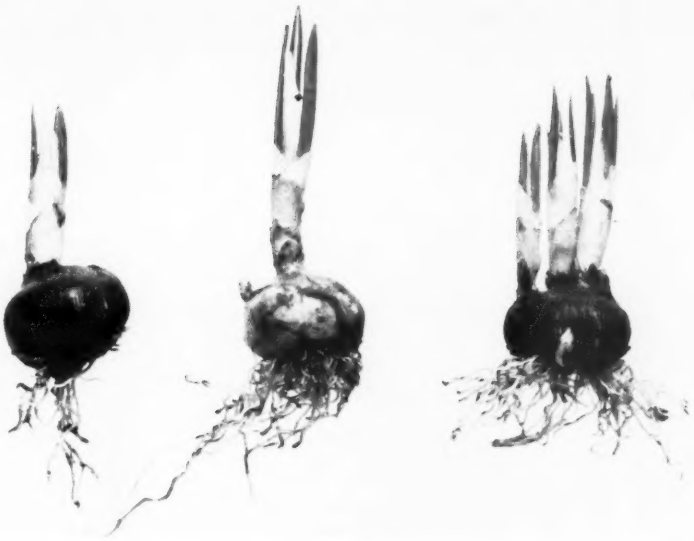
In an experiment to test the pathogenicity of the fungus, other corms of the variety Remembrance were planted one inch deep in pots of unsterilized John Innes potting compost, in November 1950, and transferred to a cool greenhouse. When strong rooting had begun, disks of maize-extract agar cultures of the *Pythium* isolated from the Leeds material, cut from the advancing edge of colonies, were inserted into the soil near and below the bases of the corms. Control pots were left untreated. All the pots were then given very heavy waterings for four days, followed by normal waterings. Thirty days after inoculation, the corms in the pots inoculated with the fungus showed severe root rotting. Infection had not been confined to the root tips, but had occurred at random along the whole length of the roots. In places, the orange-coloured lesions had girdled the roots and caused them to break off (Plate I, 1). The symptoms were similar to those in the original specimens, and the *Pythium* was re-isolated from some of the lesions. Plants left to grow on, in the inoculated pots, became stunted, and produced either abortive, under-sized flowers or none at all. The corms in the uninoculated pots remained healthy (Plate I, 2), and flowered normally.

In November 1951, similar inoculation experiments were made with *P. ultimum* on six varieties—Queen of the Blues, Vanguard, King of the Striped, Yellow Mammoth, White Mammoth and Remembrance. When examined after thirty days, the roots of all six varieties were found to be equally and extensively rotted.

I thank Mr. W. F. Buck, of this laboratory, for the photographs.

REFERENCE

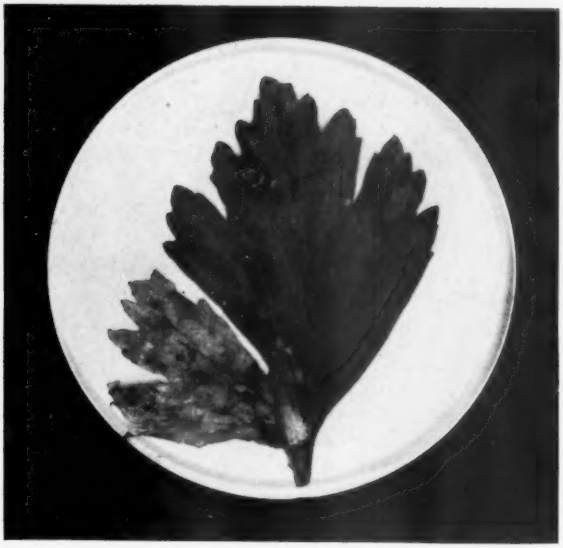
MOORE, W. C. and BUDDIN, W. (1937). A New Disease of Tulip caused by Species of *Pythium*. *Ann. appl. Biol.*, **24**, 752–61.



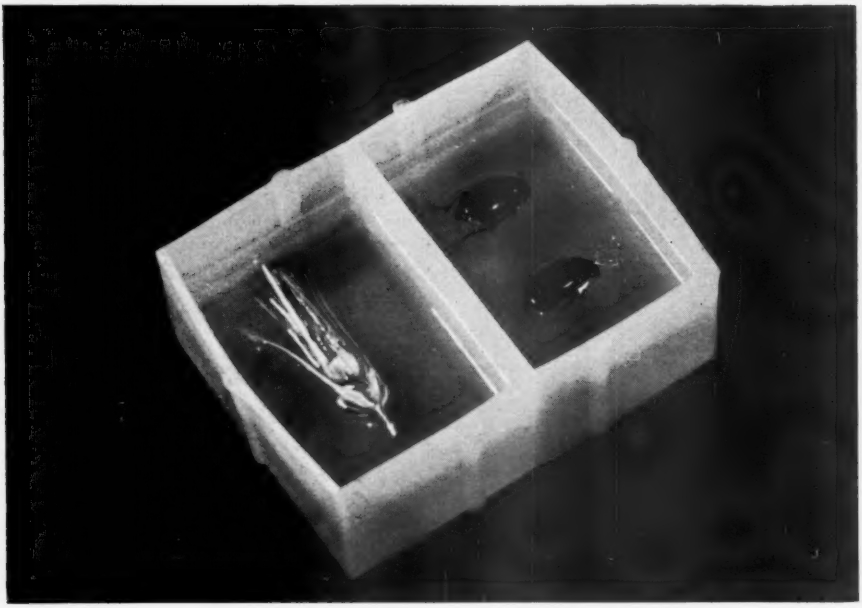
1. Crocus, var. Remembrance, showing state of roots 30 days after introduction of *Pythium ultimum* into soil of pots.

2. Crocus, var. Remembrance, showing healthy roots in control pots.

PLATE I



1. Celery leaf mined by larvae of *Philophylla heraclei* L. mounted in Marco resin using a small petri dish as mould.



2. Mounting in Marco resin, using a special twin mould, showing specimens laid on polymerized bases and secured with thin layers of pre-polymer which are allowed to set before completion of pouring.

APHIS FABAE ON FIELD BEANS (*see pp. 60–3*)

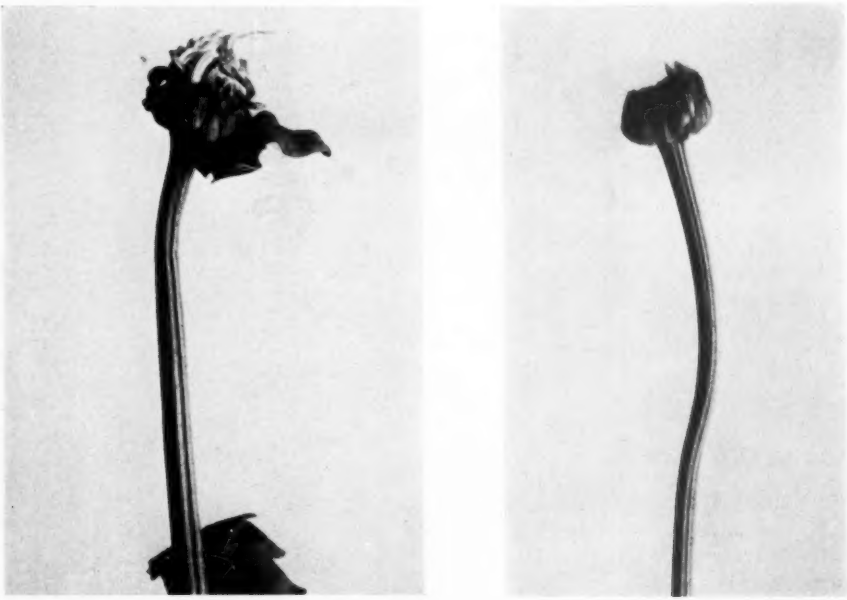
1. Alternate infested and uninfested plants in a garden plot.

UNUSUAL CHRYSANTHEMUM EELWORM SYMPTOMS (*see pp. 48–9*)

2. *Left :* Leaves showing distortion—arrows indicate "feeding areas."
Right : Shoot showing effects of apical infestation.

PLATE III

1. *Left :* Lightly infested flower showing slight abnormality.
Right : Severely infested flower showing distortion of petals.



2. *Left :* Severely infested flower, showing failure to open.
Right : Death before opening.

PLATE IV

CONTARINIA CHRYSANTHEMI KIEFFER—A NEW GALL MIDGE PEST OF SHASTA DAISY

by M. COHEN

National Agricultural Advisory Service, Newcastle-on-Tyne

In July 1951, a sample of the flowers of the Shasta Daisy (*Chrysanthemum maximum* Raymond), var. Esther Read, infested with gall midge larvae, was received from Kenton, Newcastle-on-Tyne. The grower had propagated the stock there since 1932, and until 1950 it had always flowered normally. In that year, however, a small patch of the plants produced flowers with short, withered petals. The trouble was thought to be caused by weathering, and advice was not sought until 1951, when the whole plot of approximately an acre showed similar symptoms.

SYMPTOMS AND LIFE HISTORY

Severely infested flowers often fail to open, or put forth only a few peripheral petals which do not reach their normal length and soon turn down and wither. Slightly infested flowers have the normal double appearance, but tend to be misshapen and to weather quickly. The range of damage is illustrated in Plate IV. The florets can be pulled easily from the disk, which is discoloured brown or black. The larvae may occur in large numbers between the bases of the florets or in the floret tubes, and are almost the same colour as the anthers. Some of these larvae have now been reared by Dr. H. F. Barnes, who has identified the midge as *Contarinia chrysanthemi* Kieffer.

The midges probably oviposit in the buds when these are swelling and loosening preparatory to opening. In 1951, the larvae began to leave the flowers by the middle of the third week of July and descended to the ground, where they spun white cocoons, in which they will presumably pupate in the spring. It is unlikely that there will be more than one generation in a year. Flowers and buds formed after the third week of July will generally escape damage. The larvae are pale salmon-pink to apricot-yellow in colour, and measure about 2 mm. in length by the time they are fully grown and ready to leave the flowers. They " jump " about in the typical *Contarinia* fashion.

PREVIOUS RECORDS

The species was originally described by Kieffer (1895) as : " *Eudiplosis chrysanthemi* n. sp. (D'un rouge orangé. Antennes, thorax à l' exception des côtés, bandes sur le dessus et le dessous de l'abdomen bruns. Pilosité de l'abdomen appliquée et d'un blanc argenté. Larve dans les fleures de *Chrysanthemum leucanthemum*, entre les akènes)." Kieffer (1896) sank the genus *Eudiplosis* as a synonym of *Contarinia* and so the midge must now be called *Contarinia chrysanthemi*. Kieffer (1897) also stated that flower heads of wild Ox-eye Daisy, attacked by this midge, remain closed or only half-opened and slightly swollen ; and that if the larvae are present in smallish numbers there is no malformation of the flower base, but the individual disk-florets, sucked by the larvae, are not developed normally, and do not open. He also mentioned that pupation takes place in the soil, and that he had found these gall midges at Bitche, Boulay and La Grange, all in Lorraine. No additional information appears to have been published until Bagnall and Harrison (1921) recorded

that they had found the flowers of wild Ox-eye Daisy remaining closed and rather enlarged, due to this midge, at Babbacombe, Devon, and stated that it was rare.

NEW RECORDS

In addition to that in Northumberland, there were records in 1951 from Ross-on-Wye (Plant Pathology Laboratory); Little Packington, near Stone Bridge, Warwickshire (H. C. F. Newton); and Trawscoed, Aberystwyth (P. M. Miles). In each of these cases the plant involved was Shasta Daisy. The Welsh record was for the variety Wirral Pride. Larvae of *C. chrysanthemi* were also found on the wild Ox-eye Daisy (*Chrysanthemum leucanthemum*) at Trawscoed and Llanfarian, near Aberystwyth (P. M. Miles). Although search has been made, the pest has not yet been found on the wild Ox-eye Daisy in the Northern Province.

DENSITY OF INFESTATION

A random sample of 50 flower heads in all stages of development was taken from the infested plot at Kenton on July 18, 1951. Each head was wrapped separately when picked, and each was transferred to a petri dish in the laboratory. Counts of the larvae that came out were made daily until July 26, when all the flowers were pulled to pieces and the remaining larvae were counted. 760 larvae were found, giving an average population of 14·6 per flower head on July 18. The range of population per flower head varied from 0 to 82, but these figures may be low, as 206 larvae were collected from the bench after escaping from the dishes, and these could not be referred to individual flowers.

Visual examination of the plot on July 18 showed that, up to that date, an average of 25 flowers per plant had been produced. Although not all the flowers were infested (96 per cent in the random sample), every plant carried infested flowers. A rough calculation based on the figures obtained for the random sample showed that, with about 40,000 plants per acre, the population of larvae on July 18 was in the region of 11·5 million per acre.

Soil samples (as for wireworms) were taken on September 28 and washed with a wireworm wet-extraction apparatus. The "float" was collected on a large 120-mesh sieve and spread out evenly with a fine jet of water. The midge cocoons were easily picked off and "free" larvae were also recovered. Using this method, the worst-infested plot, of the variety Esther Read, gave an average of 44·4 cocoons per sample, equivalent to 17·7 million per acre. A smaller plot of the same variety gave an average of 23 cocoons per sample, or 11·5 million per acre. A plot of the variety Wirral Pride, in which only a few of the flowers were infested, gave an average of 1·6 larvae per soil sample, or about 0·8 million per acre. The largest of the quoted figures confirms that the larvae were already leaving the flowers on July 18.

OTHER DIPTERA ON FLOWERS OF SHASTA DAISY

Larvae of two other genera of gall midges were found in material submitted to Dr. H. F. Barnes for identification. *Lestodiplosis* larvae were found in the Shasta Daisy from Northumberland. These are blood red in colour and without a breast bone or anchor process. They have the predatory head-capsule characteristic of this genus and nine pairs of ventral pseudopods. *Lestodiplosis* larvae are predatory on other gall midge larvae and also on mites. *Clinodiplosis* larvae appeared on Shasta Daisy samples from Hereford (C. A. Collingwood),

and Bangor, North Wales (F. H. Jacob). These larvae are pale-apricot in colour and possess a breast bone, but do not "jump." In this way, they can be distinguished from the *Contarinia* larvae. *Clinodiplosis* larvae are commonly found in Compositae flower heads; they usually appear to be inquilines with other gall midge larvae. The larvae of the genera *Contarinia*, *Clinodiplosis* and *Lestodiplosis* may also be easily separated by the structure of the anal segment. Figures of *Contarinia pisi*, *Clinodiplosis pisicola* and *Lestodiplosis pisi* have been given by Barnes (1938).

In addition to the gall midge larvae, a Trypetid larva also occurs in the flowers of both *C. maximum* and *C. leucanthemum*. These larvae, which are rather globular and white, cannot be confused with those of the gall midges. Usually one or two occur per head, but occasionally as many as nine have been found in a single flower. They cut their way through the base of the florets developing seeds and make a brownish-black track in the flower. Pupation occurs in the flower, the puparia being matt-black in colour. Flies emerged from the Northumberland material on August 25. They proved to be *Tephritis leontodontis* De Geer and identical with flies reared at the Plant Pathology Laboratory from similar material from Ross-on-Wye.

I am indebted to Dr. H. F. Barnes of Rothamsted Experimental Station for the identifications of the gall midges and for supplying me with the previous records of *C. chrysanthemi* Kieffer; and to the Plant Pathology Laboratory, Harpenden, for general assistance in the investigation. The soil samples were examined by Dr. W. H. Golightly and Mr. K. J. Coghill, of my staff. The photographs were taken by Mr. Coghill.

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SOME POWDERY MILDEWS ON ORNAMENTAL PLANTS

by F. JOAN MOORE

Plant Pathology Laboratory, Harpenden, Herts

SPHAEROTHECA FULIGINEA ON MARIGOLD

The frequent occurrence of a species of *Oidium* on *Calendula* in southern England was referred to by Moore (1943), who said there appeared to be no authentic record of a perfect stage having been found in this country. In May 1949, Mr. G. H. Brenchley found numerous perithecia on some severely mildewed marigolds at Combinteignhead, Devon, and sent material for identification. Only a few asci were mature and reliable measurements of the

ascospores could not be obtained, but in all other characters the fungus corresponded to *Sphaerotheca fuliginea* (Schlecht.) Salm. A few months later, I also found abundant perithecia on a severely mildewed plant in a garden in Harpenden. The spores in these perithecia were also immature but the fungus again closely resembled *S. fuliginea*. Blumer (1933) lists *S. fuliginea* as the mildew occurring commonly throughout Europe on cultivated marigolds (*Calendula officinalis* L.) and mentions that, in Switzerland, perithecia are formed only occasionally.

ERYSIPHE POLYGONI ON STATICE

A mildew has occasionally been recorded in England on species of *Statice*. It has usually been referred to *Oidium* sp., and although listed on one or two occasions as *Erysiphe polygoni*, it is very doubtful if perithecia were actually found. Salmon (1900) verified *E. polygoni* DC. on *Statice limonium* L. (syn. *Limonium vulgare* Mill.). Some very severely mildewed plants from a half-acre crop of *Statice chiloensis*, grown on a nursery at St. Albans, Herts, were brought to me in July 1950. They were coated with a felt of fungus mycelium in which were embedded large numbers of black perithecia averaging 102μ in diameter. The ascospores averaged 19 $\times$ 13μ in size and the fungus was identified as *Erysiphe polygoni* DC. Later the same year, mature perithecia, again typical of *E. polygoni*, were found by Mr. R. M. Jackson on wild sea lavender (*Limonium vulgare* Mill.) growing on a salt-marsh at Gibraltar Point, Lincs.

PODOSPHAERA OXYACANTHAE VAR. TRIDACTYLA ON CHERRY LAUREL

The status of a mildew occurring on cherry laurel (*Prunus laurocerasus* L.) in Wales was considered by Moore and Moore (1949). They suggested that the perfect stage, not yet recorded in Britain, was probably *Podosphaera oxycanthae* (DC.) de Bary var. *tridactyla* (Wallr.) Salm. which had already been found in Switzerland by Fischer (1919). In September 1951, Dr. D. L. G. Davies found a few perithecia on some leaves of severely mildewed cherry laurel bushes at Aberystwyth, Cards. As noted on previous occasions, the mildew was almost entirely restricted to the young shoots produced after very severe pruning. He tentatively identified the fungus as *P. oxyacanthae* var. *tridactyla* and sent material to me for confirmation. The perithecia, with apical appendages brown at the base and branched dichotomously several times at the tips, were characteristic of *P. oxyacanthae* var. *tridactyla*. None of the ascospores was apparently quite mature; some that were obviously nearly ripe measured 36 $\times$ 15μ—slightly larger than the measurements given by Salmon (1900).

ERYSIPHE POLYPHAGA ON KALANCHOË

In May 1951, Dr. W. W. Schwabe and Mr. I. Macfarlane showed me some plants of *Kalanchoë blossfeldiana* v. Poelln grown under long-day conditions for experimental purposes in a glasshouse at the Rothamsted Experimental Station. A mildew had been noticed on the plants for a few years but this year, for the first time, perithecia had developed and they were present in abundance. They were typical of *Erysiphe* and measured 87–120μ in diameter with an average of 102μ. There were 6–8 asci in each; the ascospores were immature. Severely mildewed chrysanthemums were present in the same glasshouse. This appears to be the first record of a mildew on *Kalanchoë* in this country and it is probably *Erysiphe polyphaga* Hammarlund. Hammarlund (1945) gave a preliminary

diagnosis of this new species in which, on the results of cross-inoculation experiments, he included the mildews on cucumber (usually referred to *E. cichoracearum*) on *Kalanchoë* (attributed to *Oidium kalanchoëae* Lüst.), on chrysanthemum (attributed to *O. chrysanthemi*) and on a number of other hosts. He described the perithecia from *Veronica speciosa* and mentioned that they had been found only very occasionally on a few of the other hosts. Apart from a reference to *Erysiphe* sp. on *Kalanchoë globulifera* var. *coccinea* in Denmark (1936), there appears to be no record of perithecia occurring on this host. Blumer (1951b) has recently confirmed that, in Switzerland also, the mildew on cucumber is polyphagous and will infect, among other plants, species of *Kalanchoë* and *Veronica*. He has occasionally found perithecia of the *Erysiphe cichoracearum* type on cucumber.

OIDIUM SP. ON LILAC

The first British record of a mildew on lilac (*Syringa vulgaris* L.) was made by Professor F. T. Brooks when he found it on a bush in a garden at Cheam, Surrey, in October, 1948. The following year I found it in September in a park near Oxford, and within a month it had been seen in several gardens in Harpenden as well as in Cambridge, in Caversham, Oxon, in another locality in Surrey, in Glamorgan and at Clophill, Beds. From September to November 1950, it was recorded again in Harpenden, Cambridge, Caversham and Clophill, and was also found in Reading, Berks, in the Isle of Wight, in Exeter and Exmouth, Devon and in Monmouthshire. Two of the affected bushes, at Harpenden and Clophill, were very severely affected and premature defoliation occurred. In contrast to the previous year, very little was seen in 1951 : no new infected bushes were recorded and of the two bushes severely affected the previous year, the one at Harpenden showed only slight infection late in the season, and up to the middle of November none had appeared on the one at Clophill. A detailed account of the distribution of a species of *Oidium*, apparently spreading in epidemic form on lilac in Europe since 1939, has been given by Blumer (1951a). No perithecia have yet been found, though some confusion has arisen because another mildew, *Phyllactinia suffulta* (Rebent.) Sacc., which produces abundant perithecia, also occurs on lilac in some parts of Europe. Blumer suggests that the fungus may be the same as the one present in America and referred to *Microsphaera alni* (Wallr.) Wint.

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TRIALS OF SUBSTITUTES FOR SULPHURIC ACID FOR POTATO HAULM KILLING

II. BLIGHT IN TUBERS

Contribution from the Conference of Plant Pathologists, National Agricultural Advisory Service, compiled by E. C. Large of the Plant Pathology Laboratory, Harpenden, Herts

As a second and collateral part of the haulm-killing trials described in the previous issue of this JOURNAL, an investigation was made by the participating Plant Pathologists of the effects of the treatments at all centres on the amount of blight in the tubers. For this purpose, tuber samples were taken from each plot and counts were made of the percentage of blighted tubers, both at lifting and after a period of storage.

An attempt was also made to relate the amount of blight in tubers at each centre, not only to variety and soil cover, but to the amount of blight on the haulm when the haulm destruction was done, and to conditions at lifting. Haulm destruction, as a measure for the prevention of blight in tubers, has two main purposes, namely, to reduce the period during which tubers are subject to *infection in the soil* by spores washed down from blighted foliage, and to prevent *infection at lifting*. To reveal the extent to which these two beneficial functions of haulm destruction were operative at each centre, successive assessments of blight on the haulm in the control plots were made at fortnightly or shorter intervals with the aid of the key (*Trans. Brit. mycol. Soc.* 1947, **31**, 140) now adopted by the N.A.A.S. Disease Assessment Committee.

The blight progress curves, plotted from these assessments, are given in Fig. 1, and the dates of haulm destruction and lifting, in relation to the progress of blight, are clearly indicated by inverted and upright arrows respectively. In planning the trials, the dates on which burning-off and lifting should be done were not laid down in advance. This was left to the discretion of the farmers and those in local charge of the trials, so that the effects of haulm destruction could be seen under a variety of local conditions as they occurred in practice, in 1951.

It was fortunate that most of the trial centres were within the zones covered by synoptic weather stations participating in investigatory work now in progress on Potato Blight forecasting. This not only facilitated the obtaining of weekly rainfall totals for plotting below the blight progress curves—to indicate the periods during which washing down of spores was most likely to have occurred ; it also made it possible to indicate on the diagrams the main periods of high humidity favouring the outbreak of blight and its rapid epidemic spread on the haulm after the outbreak. During these " Beaumont periods " (when the relative humidity in screens at the weather stations did not fall below 75 per cent, and the air temperature was not less than 50° F. for 48 hours or more), blight already established on the haulm could be expected to be in active sporulation ; and where the soil texture and cover of the tubers was such that tuber infection could occur, it was especially likely to have been initiated at such times, given the necessary rain for the washing down of spores.

At each centre, five sample runs of five plants, located at random in each plot, were lifted by hand at or about the date on which commercial lifting began.

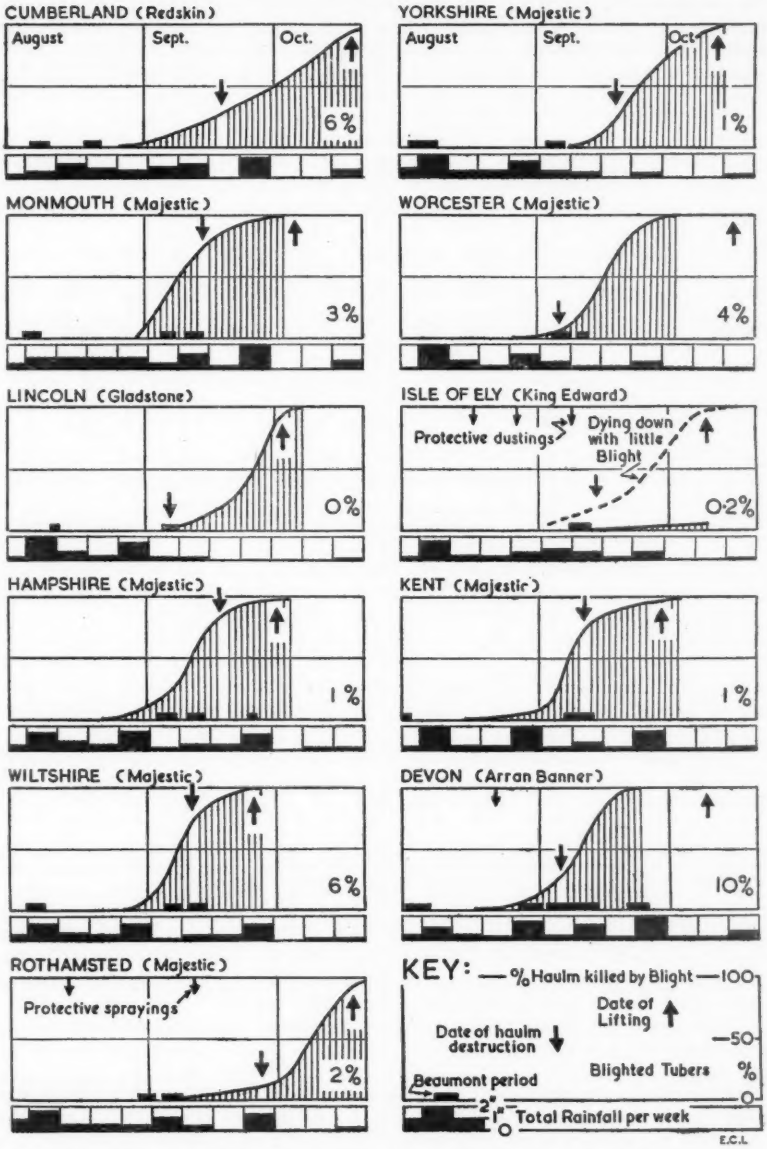

Fig. 1. Progress of blight on haulm, dates of haulm destruction and lifting, and rainfall, in relation to general level of blight in tubers at each centre, 1951.

The number of blighted and healthy tubers in each five-plant sample, excluding chats, was counted. The tubers from the five samples from each plot were then bulked, and, after storage in sacks for six weeks, a recount was made to test for infection which was not apparent at lifting but which had developed during storage.

TABLE 1

PERCENTAGE OF BLIGHTED TUBERS IN TRIALS AT 11 CENTRES, 1951

Upper figures : at lifting. Lower figures : after storage

Centre	Cumb	Yorks	Mon	Worcs	Lincs	Ely	Hants	Kent	Wilts	Devon	Roth.
Variety ..	Rdskn.	Maj.	Maj.	Maj.	Glad.	K.E.	Maj.	Maj.	Maj.	A.Ban.	Maj.
Treated ..	17.ix	18.ix	14.ix	5.ix	7.ix	14.ix	17.ix	10.ix	11.ix	4.ix	26.ix
Lifted	19.x	8.x	1.x	5.x	1.x	8.x	1.x	28.ix	25.ix	9.x	18.x
Sulphuric acid ..	—	0·0	—	3·1	0·0	0·0	1·7	1·7	2·2	10·0	2·2
	6·0	0·0	—	3·1	0·0	0·4	1·7*	2·1	4·3	10·6	1·5*
TOF 54 ..	—	1·2	2·9	5·2	0·0	0·0	0·7	0·9	2·3	7·9	1·1
	—	1·2	2·9	5·2	0·0	0·0	1·4	0·9	6·6	8·8	0·3
Sodium arsenite	—	0·8	—	3·6	0·0	0·0	1·7	0·5	1·7	14·5	1·1
	11·0	0·8*	—	3·6	0·0	0·0	2·8	0·5	8·6	15·0	0·6
TAC 49 ..	—	0·4	2·2	2·9	0·0	0·0	1·1	1·0	1·2	6·3	0·7
	5·7	1·5	2·2	2·9	0·0	0·0	1·7	2·0	3·7	6·8	0·7
Sodium chlorate	—	0·0	2·4	7·0	0·0	0·0	0·7	0·5	0·0	8·0	1·8
	4·7	0·0	2·4	7·0	0·0	0·4	0·7	0·5	0·5	8·0	1·2
Mechanical	—	0·3	1·1	4·9	0·0	0·4	—	1·3	1·7	11·5	3·0
destruction	—	0·3	1·6	4·9	0·0	0·4	—	1·7	14·3	13·6	0·7
Control	—	0·5	3·4	0·9	0·0	0·7	0·6	0·5	1·1	9·8	2·0
(untreated)	5·6	2·4	3·4	1·3	0·5	0·7	1·1	1·1	6·8	10·7	0·5
Mean, all plots ..	—	0·5	2·4	4·0	0·0	0·2	1·1	0·9	1·5	9·7	1·9
	6·6	0·9	2·5	4·0	0·1	0·3	1·3	1·2	6·4	10·5	0·8

* Where the recounts were less than the original counts, owing to loss of tubers by soft rot and other causes, the upper figures are repeated. Counts for blight after storage, at Rothamsted, were not made on the same tubers as at the sample lifting, but on one hundredweight samples taken during commercial lifting.

At all the centres there was much variation in the number of blighted tubers found in the five sub-samples for each plot, and, as Table 1 clearly indicates, there was no significant difference between the mean percentage of blighted tubers in the control and treated plots at any of the centres. Even with sulphuric acid, which gave the most rapid kill, the percentage of blighted tubers was about the same as in the control plots.

The particular seasonal and local conditions under which this result was obtained may be seen by reference to Fig. 1. Blight was late in starting on the haulm, but it made unexpectedly rapid progress during an unusually warm and humid spell in early September, and most of the haulm even in the control plots was dead by the end of September at all centres. There was dry weather for lifting in October. Haulm destruction at all the centres was delayed until September—partly for the reason that the potatoes bulked late after a cold spring. At all except two of the centres (Lincoln and the Isle of Ely, where

blight in tubers was nil or negligible) there had been two to four weeks during which blight was actively sporing on the haulm, and considerable rain to wash spores down into the soil, *before* haulm destruction was done, and although there were differences in speed of kill of the haulm with the several treatments *after* the date of haulm destruction, this made little or no difference to the ultimate amount of blight in the tubers. In another season, with a more lingering blight attack, other weather conditions, and other timing of the haulm destruction, very different results may be obtained ; but in 1951, none of the treatments at any of the centres had any appreciable effect on the amount of blight in the tubers, and the sole value of the haulm destruction was in facilitation of lifting.

OTHER FACTORS AFFECTING BLIGHT IN TUBERS

The diagrams of Fig. 1 point to factors, other than haulm destruction, affecting the general level of blight in the tubers at the several centres.

At the Isle of Ely centre, on King Edward, late protective dustings kept the haulm almost free from blight up to the date of lifting, and here, despite some exposure and thin cover of the tubers owing to the normal weathering of well-made drills on fen soil, the amount of blight in the tubers was negligible. At Lincoln, on both Gladstone and Arran Peak, with little rain over the period during which there was blight on the haulm, and with good coverage on a light acid peat soil, there was no blight in the tubers.

The conditions at these two centres may be contrasted with those in Cumberland and Devon, where the percentage of blight in tubers was fairly high. In Cumberland, on Redskin, the progress of blight on the unsprayed haulm was long-drawn-out, and there was much rain during the early part of the attack to wash spores down into the soil, which was mostly peat and of open texture. In Devon, on Arran Banner, the single protective spraying, given after the outbreak of blight, had little retarding effect, and with long humid periods and much rain, there was again abundant opportunity for spores to wash down into the soil during the early part of the attack. The soil at this centre was a granite loam, and rather shallow earthing-up gave inadequate tuber cover in places.

At all the other centres the trial variety was Majestic and, with rather similar blight conditions, the general level of blight in the tubers ranged from 1 per cent at the Yorkshire and Hampshire centres, where the soil cover over the tubers was very good, to 6 per cent at the Wiltshire centre, where the soil cover was shallow, owing to subsidence of the drills on a light greensand soil. The diagrams show that at all these centres there was considerable opportunity for washing down of spores on to the soil before the date of burning off.

It was observed at most centres that blight on the haulm cut by mechanical means was still sporing on the debris in the furrows up to a fortnight after cutting, but under the conditions of the trials in 1951 there was no difference between the amount of blight in the tubers following mechanical haulm destruction, chemical haulm destruction, or the " biological haulm destruction " which results from leaving the haulm to be killed off by blight itself.

It must be stressed that this contribution presents results obtained in 1951 only. Very different results may be obtained in other years. The work is being continued. Acknowledgments, and names of those co-operating in 1951 have been given in the first part of this contribution (*Plant Pathology*, 1952, **1**, 4–10).

THE EFFECT OF *APHIS FABAE* SCOP. ON THE GROWTH AND YIELD OF FIELD BEANS IN A GARDEN PLOT

by E. JUDENKO, C. G. JOHNSON, AND L. R. TAYLOR

Department of Entomology, Rothamsted Experimental Station, Harpenden, Herts

The Black Bean aphid, *Aphis fabae* Scop. can often cause complete failure of the crop with field beans, but we know of no estimates of yield in relation to a known infestation of less severity. This paper describes such an assessment which was made, in 1948, on a plot of field beans in a garden where alternate plants were kept free from aphids. The results would not necessarily have been the same with crops grown in the field with infestations occurring in patches, and where plants would be more crowded.

No doubt a more satisfactory experimental procedure would have been with randomized blocks, infested and controls, on a field scale ; for it is possible that, with the present experiment (with alternate plants as controls), controls and infested plants may have had some compensatory effect upon each other's growth. Work on a field scale was, however, impracticable ; moreover, the present work shows that since quite a small infestation may produce an appreciable effect, very great difficulty might be encountered in keeping adequately clean controls in the field.

EXPERIMENTAL METHODS

The plot (thirty feet square), was in a sheltered garden at Rothamsted Lodge, the ground being ploughed and dressed with farmyard manure at the rate of ten tons per acre, on March 16, 1948.

The bean used was a tick bean supplied by the National Institute of Agricultural Botany (Ref. BEN 34 or 36), and was not known to possess any special qualities of resistance or susceptibility to black bean aphid. The seeds were soaked on March 15, and planted in an unheated greenhouse on March 16. When the plants were 2–5 in. high, approximately 250 were transplanted out-of-doors in rows two feet apart, with two feet between plants. It was to facilitate inspection, and to reduce the risk of infestation of controls from adjacent colonies, that the plants were spaced at this interval. Four days before transplanting (April 13), potassium sulphate was scattered evenly over the plot at a rate of 2–3 cwt. per acre.

The first primary migrants arrived on May 8, and by May 13, 87 per cent of plants, other than controls, were infested. The primary migration ceased towards the middle of June. During this period, each plant was inspected daily, and from the same alternate plants (controls), all aphids were removed by hand-picking. The remaining alternate plants v e allowed to develop infestations unhindered.

On June 29, the heights of all the stems were measured from ground level to the extended tip of the highest leaf ; side-shoots originating within 10 in. of the ground were included.

HARVESTING

At the end of the experiment the plants were allowed to die back, and were harvested on September 8 and 9. Each plant was carefully bound with string, pulled up, labelled, stacked in an outside verandah under shelter (beyond reach of mice), and allowed to dry. A few beans were unavoidably lost during harvesting and drying, but a correction showed the effect of this loss to be negligible : similarly the loss due to birds during the growth of the crop was negligible. Bean pods were taken from the plants and stem lengths measured from stock (or axil in lateral branches) to tip on October 1, after several days of dry weather. Pods were stored in envelopes in the laboratory, and were finally counted and weighed in the following January.

PROGRESS OF THE INFESTATION

During the build-up of aphid populations, the controls were kept free from aphids by daily hand-picking. On June 15, however, a few controls had developed small infestations, of up to 1 in. long, in the crown of the plants. In order to eliminate these without injury to the growing point, the individual crowns were carefully sprayed from very close range with nicotine emulsion.

Between June 27 and 29, an assessment was made of the aphid population on the infested plants of the first 10 rows. (The remaining 6 rows were not assessed owing to the very rapid decline of the population, the plot becoming almost free from living aphids in 3 or 4 days.) The results were as follows :

14 stems with no infestation.

66 stems with slight infestation—up to about 30 aphids in the crown of the stems.

32 with considerable but scattered infestations too large to count, too diffuse to measure linearly.

155 with measurable infestations—typical, closely packed, from the crown down the stem, varying from 3 to 25 cm. in length (average 11·5 cm.) (Fig. 1).

The attack was thus relatively light, and of short duration in its heavier phase; the assessment was, moreover, made at the height of the infestation. Even where closely-packed and measurable colonies existed, it was uncommon for all four sides of the stem to be heavily infested ; frequently, only one side bore the colony. In a heavy infestation, it would have been common for large colonies to exist on most plants, with an average of at least 25 cm.

EFFECTS OF THE INFESTATION ON THE CROP

By June 29, the effects of the infestation were visible (Pl. III, 1), and showed a statistically significant reduction in mean total stem-length per plant of 22 per cent as compared with controls ; there was also a significant reduction of 11 per cent in the mean number of stems per plant (Table 1). Plants continued to grow, however, after all living aphids had disappeared, and ultimately, the difference in mean total stem-length per plant was only 9 per cent, although the *mean individual* stem-length showed a 15 per cent difference (Table 2). At the end of June, the controls had slightly more stems per plant, but the situation tended to be reversed by the end of the experiment.

TABLE 1

THE STATE OF INFESTED AND CONTROL PLANTS, JUNE 29, 1948

	Control	Infested
Number of plants	117	120
	Mean and Standard Deviation	Mean and Standard Deviation
Number of stems per plant	3·74± 1·20	3·32± 1·10
Total stem length per plant (cm.)	273·1 ±57·03	212·8 ±73·78

The yield was greatly reduced on the infested plants, the mean weight of beans per plant being 58·7 grm. for controls, and 33·3 grm. for infested plants—a reduction of 43 per cent (Table 2). This was associated with a smaller number of pods per plant (difference of 38 per cent), a smaller number of beans per plant (difference of 39 per cent), a smaller number of locules per pod (2 per cent) and with smaller beans (difference of 7 per cent), for infested as compared with uninfested plants. As would be expected from widely varying degrees of infestation, there was a greater variation in size of plants and weight of beans on the infested plots than on those of the control ; but, in considering the size of individual beans, it was found that the bigger degree of variation was in the controls (as shown by the coefficient of variation, $\frac{SD}{mean} \times 100$, from Table 2).

TABLE 2

FINAL COMPARISON OF INFESTED AND CONTROL PLANTS

	Control	Infested
Number of plants	115	118
	Mean and Standard Deviation	Mean and Standard Deviation
Number of stems per plant	4·03± 1·57	4·35± 1·97
Individual stem-length (cm.)	126·09± 32·38	106·62± 32·17*
Total stem-length per plant (cm.)	507·6 ±195·19	463·5 ±281·76*
Number of pods per plant	46·8 ± 21·21	28·9 ± 17·41*
Number of beans per plant	141·1 ± 67·06	85·9 ± 54·37*
Weight of beans per plant (grm.)	58·7 ± 31·14	33·3 ± 23·52*
Weight per bean (grm.) from 120 groups of seven beans	0·42± 0·82	0·39± 0·22*
Number of locules per pod	3·21± 0·99	3·14± 1·02*

* Significant at 5 per cent level.

A notable feature of the comparison of infested and clean plants is the existence of some very heavily-infested plants, which were usually large, and produced almost as great a weight of beans as similar clean controls ; this suggests that some individuals can resist attack.

This experiment shows that, even with only a very moderate infestation over a two-month period from the beginning of the attack, and with a good opportunity for the plants to grow for two months after the disappearance of the

infestations, the reduction in yield was 43 per cent ; it must be reiterated that these results should not be extrapolated to infestations in the field without further study.

RELATIONS BETWEEN INFESTATION, YIELD AND SIZE OF PLANT

It was first thought that, if the graph for yield on degree of infestation was extrapolated to the point of zero infestation, it might be possible to obtain an *estimate* for the yield of clean plants, thus eliminating the use of controls in larger field experiments, where difficulty in maintaining large numbers of plants free from attack would be great. However, the large degree of variation of yields between infested plants made this impracticable. (Fig. 1 shows this relation between yield and infestation per *plant*).

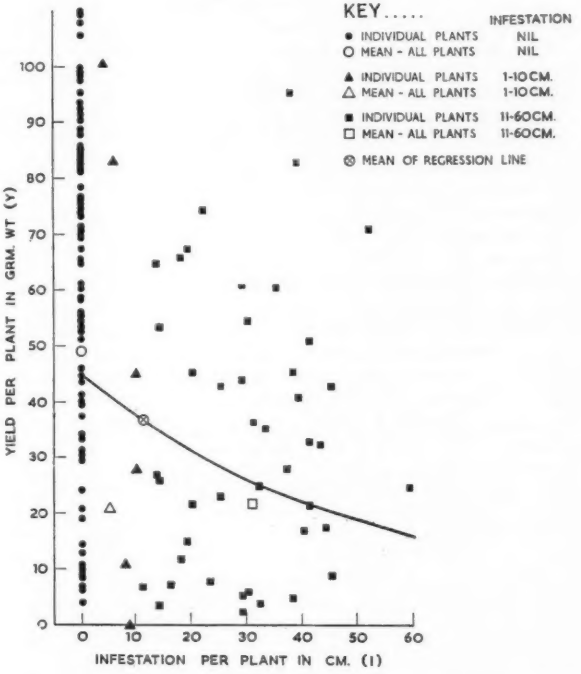

Fig. 1. Regression of yield on infestation using all available material.

A significant correlation was obtained, however, between mean individual stem-length per plant and degree of infestation using only infested plants, as well as between yield on total stem-length per plant and yield on number of stems per plant.

It is hoped that future work may show whether the relationship between these variables will allow an estimate of yield at zero infestation to be calculated indirectly with a degree of accuracy suitable for practical use.

TOMATO MOSAIC IN RELATION TO SOURCE OF SEED

by MOIRA C. D. JUSTHAM AND L. OGILVIE

National Agricultural Advisory Service, Bristol

Selman, in 1943, described trials made over a period of three years to compare the incidence of mosaic in tomato plants raised from seed taken from " virus-free " and virus-infected plants. His main conclusion was that, under commercial conditions, plants from virus-free seed are likely to remain free from mosaic longer than others, but that under exceptionally favourable growing conditions, virus-free seed is unlikely to show any advantage.

In 1948, we were able to carry out similar trials on a commercial nursery in Gloucestershire with the full co-operation of Mr. E. Lockwood, a very experienced grower. He, and several other growers, provided us with random samples from their own bulk selections of good commercial seed, four of which we included in our trial (K, L, M and N). Our virus-free seed, of which we had seven samples (A to G), was taken from parent plants chosen for the healthy appearance of their foliage, all of which gave negative results when extracts of their leaf tissues were tested for anisotropy of flow.* We also included one sample of virus-free Cheshunt ES 4(J); some old seed of Cheshunt ES 1 (H), and, for comparison, a sample taken from a plant showing pronounced mosaic symptoms and positive by the anisotropy test. The plants from all the samples of seed were raised on the nursery. The grower, who is a non-smoker, dealt with the experimental material himself, and was scrupulous in taking such precautions as washing his hands after working on one block of plants before moving on to the next. Both the propagating soil, and the soil in the two houses devoted to the trial, were steam-sterilized before taking the experimental crop. Propagating benches and pots were treated with formaldehyde. The seeds were sown about the end of February in separate lots of 80 to 100 seeds per sample. They were pricked out singly in pots which were spaced out to prevent contact of foliage. On April 6, the plants were 6 in. high, and all appeared healthy. Anisotropy tests, on tissue extracts from two plants in each batch, were negative. On April 10, the plants were set out in blocks of 24, in two adjacent houses, thus :

House 1		*House* 2	
G.	Unknown variety.	H.	Cheshunt ES 1 (old seed).
F.	Clibran's Victory.	I.	Seed from plant with Mosaic.
E.	Clibran's Victory.	J.	Cheshunt ES 4.
D.	Grower's var.	K.	Bulk selection.
C.	Grower's var.	L.	Bulk selection.
B.	Carter's Sunrise.	M.	Bulk selection.
A.	Stonor's Exhibition.	N.	Bulk selection.

* This test for Tobacco Mosaic Virus, Potato Virus X, and other viruses having rod-shaped particles, is described by F. C. Bawden, in Plant Viruses and Virus Diseases, 3rd edition, *Chronica Botanica*, 1950. Our method of carrying out the test was to grind the leaf tissue, squeeze out the sap, heat to 60° C. for a few minutes with constant stirring, cool under the tap, centrifuge for 15 minutes at 2,000 r.p.m., pour off the supernatant liquid, and examine it, in a tube placed between two crossed Polaroid screens, in front of a lamp.

On April 28, representative leaves from each block were again tested by the anisotropy method, with negative results. On June 17, mosaic mottling was apparent in blocks A, C, G, H and L, and anisotropy tests on leaves from these blocks were positive. By June 23, when the first fruits were being picked, mild mottle was widely distributed throughout all the blocks and was equally severe in both houses.

Thus, in spite of great care in handling each batch of plants separately, washing the hands between each batch, segregating the possibly infected lots in a different house from those possibly virus-free, the use of new fillis, and allowing no smokers to handle the plants, mosaic, though rather late, ultimately appeared in all sets of plants. The distribution of the first plants to show mosaic bore no relation to the source of seed. Growing conditions in the houses could not be described as " abnormally " favourable, but the general vigour of the plants was very good. The nursery is one in which tomato mosaic frequently occurs ; steam sterilization is a regular practice.

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PRESERVATION OF INSECT AND PLANT SPECIMENS IN TRANSPARENT PLASTICS

by PHILIP M. MILES

National Agricultural Advisory Service, Aberystwyth

Embedding of biological specimens in transparent synthetic resins is one of the most important developments in museum technology, and is often of great value to those engaged in teaching or advisory work. Two suitable materials now available in this country are methyl methacrylate (" Perspex "), giving blocks which are colourless and crystal clear ; and Marco Resin S.B.26C, giving blocks of a slightly greenish tinge, but having the advantage that it polymerizes at room temperature without the aid of special apparatus, and that plant specimens may be mounted in it, from water, without dehydration. I have obtained satisfactory results with both materials, and this is an account of the methods I have used, with a few explanatory notes.

EMBEDDING IN METHYL METHACRYLATE*

Caution. All work with the methyl methacrylate monomer should be done in a fume cupboard fitted with an efficient exhaust fan to remove the poisonous and inflammable vapour. The use of naked flames should be avoided.

* The monomer is obtainable from Imperial Chemical Industries Ltd., under the trade name " Kallodoc."

Pre-Treatment of the Monomer. " Kallodoc " contains an inhibitor which must be removed before polymerization is possible. In preparation for use, the material (100 c.c.) is vigorously shaken in a separating funnel with three aliquots of 5 per cent sodium hydroxide (40 c.c.) or until the alkali layer is colourless. The monomer is then washed with distilled water until it is alkali-free, and finally dehydrated by standing over anhydrous calcium chloride overnight.

Preparation of the Pre-Polymer. To enable the monomer to polymerize at temperatures suitable for the embedding of biological material, it is necessary to add a catalyst. For this purpose, the dry monomer (200 c.c.) is shaken with benzoyl peroxide (0·2 grm.) until all traces of solid have disappeared, and then filtered into a conical flask (300 c.c.) fitted with an air condenser. The flask is heated on a water bath to 80° C., with care not to exceed that temperature, and shaken every four minutes for about 20 minutes, until the contents start to thicken. The flask is then shaken vigorously at least every two minutes until the desired consistency is reached. Subsequent operations are facilitated if two batches are prepared, one of the viscosity of glycerine, and the other of treacle. Polymerization is retarded by putting the batches into a refrigerator, and storing at — 4° C. until they are required for use. Overheating must be avoided at all stages of the preparation, as it causes excessive bubbling, and usually results in too complete pre-polymerization and wastage.

Preparation of Moulds. Glass moulds may be helpful where mechanical means of grinding and polishing the cast blocks are not available, but for work with methyl methacrylate, the writer prefers frames made of strips of stout cardboard, wrapped with thin cellulose film, and stood, over a smooth surface, on sheets of the same film, the edges of which are turned up to encase the frames, and are held thereto by encircling rubber bands. A sheet of cellulose film is similarly held over the top of the mould to check evaporation and to exclude dust.

Preparation of Specimens. Only completely dry specimens can be satisfactorily embedded in methyl methacrylate. The types of specimen most easily dealt with include such plant materials as seeds, twigs, sections of timber, everlasting flowers (which can be dried without undue distortion or discoloration), shells and bones, and insect specimens that have been set and dried as for normal display purposes. Such specimens are prepared for embedding by injecting cavities, where necessary, with inhibitor-free uncatalysed monomer, and then leaving them in this monomer, under reduced pressure in a vacuum jar, until they are completely impregnated. The specimens are then transferred to thin pre-polymer and again subjected to reduced pressure. Green plant material turns yellow in methyl methacrylate, and special methods, as described by Fessenden (1949), are necessary for the preservation of natural colour. Methods for mounting the larger fungi are described by Hutchinson (1950).

Embedding the Specimens. A base for the specimen is first formed by pouring some of the prepared pre-polymer, of the viscosity of treacle, into a suitable mould to a depth of about half an inch, and then polymerizing this layer until it gels. The polymerization, in this and in later stages of the process, may be effected by carefully controlled heating in an oven at 45° C., but the writer has used irradiation by a 300-watt " Hanovia " ultra-violet lamp. With a Wood's glass filter, it is possible to place the moulds nine inches from the lamp with little risk of bubbling ; but, without a filter, the writer has exposed the moulds (with their dust covers removed) for two periods of an hour each day, in the morning and in the afternoon, at a distance of 2 feet 6 inches from the lamp, keeping the moulds under close observation and withdrawing them a little

before the required degree of polymerization has taken place, as the action continues for a short time after the exposure. As soon as the base is sufficiently firm, a thin layer of pre-polymer, of the viscosity of glycerine, is next poured ; the specimen is put into position and arranged ; and then more of the pre-polymer is poured round it until it is just covered but not floating. The whole preparation is put under reduced pressure in a vacuum jar overnight to withdraw any air bubbles, and then subjected to further periods of exposure to ultra-violet light. When the intermediate layer is nearly hard, a final layer of pre-polymer is poured, covering the specimen to the depth required, and intermittent exposure to ultra-violet light is continued until the whole block is hard—a block 3 inches × 1 inch × 1½ inches takes about a week. The mould is then stripped away, and the block is ready for grinding and polishing. Great care must be taken, throughout the embedding process, to avoid too rapid polymerization through over-exposure to the ultra-violet light, as this will cause bubbling and spoil the preparation.

EMBEDDING IN MARCO RESIN S.B. 26 C*

The technique of embedding in this material is described by Purves and Martin (1950). The mixture before polymerization has a strong odour resembling that of coal gas, and preparations are best kept in a fume cupboard or under bell jars until the blocks have set. After use with the material, all apparatus remains almost permanently sticky unless washed with acetone followed by hot soapy water.

Preparation of the Pre-Polymer. With this material, there is no inhibitor to be removed, and the pre-polymer is very easy to prepare. The required quantity of the monomer (embedding mixture) is weighed into a clean beaker, and for each gram, 3 drops of hardener are added with a special pipette. Alternatively, 1 part of hardener is added to 7 parts of embedding mixture, by weight. The preparation is stirred and is then ready for use. Polymerization takes place in two to three hours at room temperature, without irradiation. On warming, the polymerization proceeds more rapidly ; at 60° C., it is possible to completely polymerize a block in just over a quarter of an hour ; but hastening of the process is inadvisable owing to the risk of overheating and cracking.

Preparation of Moulds. As this material, before polymerization, is of low viscosity and high specific gravity, well-constructed moulds are necessary. Glass dishes are suitable, and special plastic moulds, which may be used repeatedly, are obtainable from the manufacturers (Plate II).

Preparations of Specimens. Dry specimens, such as shells, insects set and mounted for museum cases, seeds, dried leaves of plants and ears of cereals, require no further preparation. Wet specimens may be mounted after fixation, but fixatives should be removed by washing in water. Formaldehyde, alcohol and picric acid inhibit polymerization of the resin. The green colour of plant specimens may be preserved by steeping them for from three to seven days in a solution prepared by bubbling sulphur dioxide from a siphon into 750 c.c. of 2 per cent copper sulphate solution until the volume increases to 755 c.c. Specimens treated by this process retain their colour well in S.B. 26 C., if first fixed for up to two months in strong formaldehyde (1 part of 40 per cent formaldehyde in 5 parts of water, by volume), washed in water, blotted dry, and then wet-mounted. Transparent mounts of suitable subjects may be

* Supplies of this embedding mixture and the hardener for use with it, manufactured by Scott Bader & Co. Ltd., are obtainable, together with special apparatus, from E. M. Cromwell & Co. Ltd., Bishops Stortford, Herts.

obtained by dehydrating the specimens, after fixation and washing in water, by passing them through an alcohol series—10, 30, 50, and 90 per cent and absolute, are generally sufficient—followed by anhydrous ether, in which they are kept until mounting.

Embedding the Specimens. A base is first poured, and when this has set, the specimen, wet or dry, is placed in position. For wet mounts, the specimen is merely removed from water, drained, and blotted as dry as possible. A little pre-polymer is then freshly prepared and poured round the specimen, taking care not to use enough to cause it to float. When this layer has hardened, further layers are poured to complete the embedding. Pouring to a depth of more than three-quarters of an inch may result in fracture of the block through internal stresses. If a dried specimen, such as a piece of bone, is mounted in an opaque condition, a certain amount of air will be retained in it, which may expand and crack the block unless embedding is done in several stages. For transparent mounts, the specimen is transferred from ether to embedding mixture without hardener and allowed to stand until clear. Impregnation may be hastened by putting the preparation under reduced pressure, but care must be taken not to allow the ether to boil, as this may damage the specimen. When clear, the specimen is placed on a polymerized base, completely covered with pre-polymer, and set aside to harden.

GRINDING AND POLISHING THE BLOCK

Where only a few small blocks have to be made occasionally from S.B. 26 C, it is quite practicable to grind and polish them by hand, but in the case of methyl methacrylate blocks, owing to the irregular nature of the surfaces, the use of a mechanical grinder is definitely to be recommended.

Large pieces of unwanted plastic are cut away with a hack-saw, and then, in hand grinding, the surfaces of the block are rubbed down in turn on coarse, medium, fine and very fine grades of hydraulic emery paper. It is important to secure the emery paper on a flat surface and to use plenty of water when grinding to minimize scratching from loose abrasive. The rubbing should be done in one direction, preferably along a straight edge to avoid cross scratches. When a satin-like finish has been produced on all surfaces by using the finest obtainable grade of emery paper, the work may be completed by rubbing with brass polish on wash-leather, or with putty powder.

In mechanical grinding, the block is held against the side of a medium grade emery wheel or sanding head which should not be run too fast as overheating of the block will cause bending and scoring. A satin-like finish, in the absence of a band grinding machine, is obtained by hand grinding on fine grades of hydraulic emery paper. A final finish like that of glass is obtained by holding the block lightly to the side of a calico polishing wheel to which a suitable buffing soap has been applied. Good results may also be obtained by applying fat as an adhesive to the polishing wheel and using whiting as a polishing compound.

I thank Dr. D. L. G. Davies for the photograph reproduced in Plate II, 1, and Mr. W. F. Buck for that in Plate II, 2.

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